OUTLINES

OF

AGRICULTURE

ADDRESSED TO

SIR JOHN SINCLAIR, BART.

PRESIDENT

OF

THE BOARD OF AGRICULTURE.

BY A. HUNTER, M. D. F. R. S. L. & E.

"It is the Earth that, like a kind Mother, receives us at our Birth, and ſuſtains us when "Born. It is this alone, of all the Elements around us, that is never found an Enemy to Man. "The Body of Waters deluge him with Rains, oppreſs him with Hail, and drown him with "Inundations; the Air ruſhes in Storms, prepares the Tempeſt, or lights up the Volcano; "but the Earth, gentle and indulgent, ever ſubſervient to the Wants of Man, ſpreads his Walks "with Flowers, and his Table with Plenty; returns, with Intereſt, every good committed to "her Care; and though ſhe produces the poiſon, ſhe ſtill ſupplies the Antidote; though con- "ſtantly teaſed more to furniſh the Luxuries of Man than his Neceſſities, yet even to the laſt "ſhe continues her Indulgence, and when Life is over, ſhe piouſly hides his remains in her "Boſom."

PLIN. NAT. HIST. L. II.

YORK:

PRINTED BY WILSON, SPENCE, & MAWMAN;

AND SOLD BY CADELL, JUN. AND DAVIES, LONDON.

Anno 1795.

TO

SIR JOHN SINCLAIR, BART.

SIR,

THE Board of Agriculture owes its origin to your patriotic exertions, and as I have the honour of being a Member of that diſtinguiſhed body, I conſider myſelf as bound to depart a little from the line of my profeſſion, in order to promote the views of an inſtitution, which evidently has the general good of mankind for its object.

I am, Sir,

Your moſt obedient ſervant,

YORK, Jan. 1, 1795.

A. HUNTER.

OUTLINES OF AGRICULTURE.

THE Art of Hufbandry boafts an origin coëval with the human race. Its age, however, feems to have contributed but little towards its advancement; being at prefent extended but a few degrees beyond its primitive inftitution.

Until the Philofopher condefcends to direct the plough, Hufbandry muft remain in a torpid ftate. It is the peculiar happinefs of this age, that men of a liberal education begin to cultivate this art with attention. The Board of Agriculture has already raifed a fpirit of emulation among our country gentlemen and fenfible farmers. Each feems envious of contributing fomething towards the general ftock of knowledge. Such a pleafing intercourfe cannot fail of fpreading the improvements in Agriculture over the moft diftant parts of this ifland.

I take upon me to ſay, that, to be a good huſbandman, it is neceſſary to be a good chymiſt. Chymiſtry will teach him the beſt way to prepare nouriſhment for his reſpective crops; and to this circumſtance the farmer ought diligently to attend, for it is well known that vegetables, as well as animals, have a diſpoſition to prefer one kind of food to another.

It is alſo neceſſary for the huſbandman to be a good mechanic, in order to be a judge of the inſtruments employed in dividing and looſening the ſoil; an operation of the greateſt uſe to the farmer.

The ingenious Dr. Home has opened to our view a noble field for improvement. His reaſoning is juſt and concluſive; but it were to be wiſhed that his experiments had been conducted upon a larger ſcale. However, contracted as they are, they will be found of great uſe to whoever intends to purſue the ſtudy of Agriculture upon rational principles.

In regard to what I ſhall obſerve on the nouriſhment of plants, it will be proper to ſay, that I have been directed in my reſearches by a ſtrict attention to the analogy that ſubſiſts between animals and vegetables. We know that neither of them can ſubſiſt long without air and nouriſhment. Directed by inſtinct, the animal ſeeks its own

proper food; but the vegetable, not being poffeffed of the power of motion, muft be fatisfied with the nourifhment that we give it.

I lay it down as a fundamental maxim, that all plants receive their principal nourifhment from oily particles incorporated with water, by means of an alkaline falt or abforbent earth. Till oil is made mifcible, it is unable to enter the radical veffels of vegetables; and, on that account, Providence has bountifully fupplied all natural foils with chalky or other abforbent particles. I fay natural foils, for thofe which have been affifted by art are full of materials for that purpofe; fuch as lime, marl, foap-afhes, and the volatile alkaline falt of putrid dunghills.

It may be afked, whence do natural foils receive their oily particles? I anfwer, the air fupplies them. During the fummer months, the atmofphere is full of putrid exhalations, arifing from the fteam of dunghills, the perfpiration of animals and fmoke. Every fhower brings down thefe oleaginous particles for the nourifhment of vegetables.

Of thefe particles fome fall into the fea, where they probably ferve for the nourifhment of fuci, and other fubmarine plants. They are, however, but feemingly loft, as the fifh taken from the fea, and the weeds thrown upon

the beach, reſtore them again under a different form. Thus Providence, with the moſt conſummate wiſdom, keeps up the neceſſary rotation of things.

When they happen to fall upon a very ſandy ſoil, the ſolar heat exhales the moſt of them. Hence an additional reaſon for covering our light ſoils with herbage during the ſummer months.

On the contrary, when they fall upon ſtiff land, or ſuch as have been marled or limed, an intimate union is produced, too ſtrong for the ſolar heat to exhale.

It is obſerved, that lime mechanically binds a hot ſandy ſoil. We now ſee that it alſo fertilizes it; but the farmer muſt not preſume too much upon that quality.

The ingenious Mr. Tull, and ſome others, contend that earth is the food of plants. If ſo, all ſoils equally tilled would prove equally prolific. The increaſed fertility of a well-pulveriſed ſoil, induced him to imagine that the plough could ſo minutely divide the particles of earth, as to fit them for entering into the roots of plants.

An open ſoil, if not too light in its own nature, will always produce plentiful crops. It readily receives the air, rains, and dews into its boſom, and at the ſame time gives the roots of plants a free paſſage in queſt of food.

This is the true reaſon why land well tilled is ſo remarkably fruitful.

It is well known that animals take in many earthy particles by the mouth, but vegetables take in the feweſt imaginable, having no way to diſcharge them. And indeed they hardly take in any, as is evident from the careful experiment made by Van Helmont, whereby it appears that a tree in the courſe of five years gained 164 pounds weight, while the earth in which it grew only loſt two ounces.

Water is thought, by ſome, to be the food of vegetables, when in reality it is only the vehicle of nouriſhment. Water is an heterogeneous fluid, and is no where to be found pure. It always contains a ſolution of animal or vegetable ſubſtances. Theſe conſtitute the nouriſhment of plants, and the element in which they are minutely ſuſpended, acts only as a vehicle, in guiding them through the fine veſſels of the vegetable body.

The hyacinth, and other bulbous roots, are known to perfect their flowers in pure water. Hence ſuperficial obſervers have drawn an argument in favour of water being the food of vegetables. But the truth is, the roots, ſtem, and flowers of ſuch plants are nouriſhed by the mucilaginous juices of the bulb, diluted by the ſurround-

ing water. This mucilage is juſt ſufficient to perfect the flower—and no more. Such a bulb neither forms ſeeds, nor ſends forth off-ſets. At the end of the ſeaſon, it appears weak, ſhrivelled, and exhauſted, and is rendered unfit to produce flowers the ſucceeding year. A root of the ſame kind, that has been fed by the oily and mucilaginous juices of the earth, eſſentially differs in every particular. It has a plump appearance, is full of mucilage, with off-ſets upon its ſides.

All rich ſoils, in a ſtate of nature, contain oil; and in thoſe lands which have been under the plough for ſome years, it is found in proportion to the quantity of putrid dung that has been laid upon them, making allowance for the crops they have ſuſtained.

To ſet this matter in a clearer light, let us attend to the effects of manures of an oily and mucilaginous nature, and we ſhall ſoon be ſatisfied that oil, however modified, is one of the chief things concerned in vegetation.

Rape-duſt, when laid upon land, is a ſpeedy and certain manure, though an expenſive one, and will generally anſwer beſt on a limeſtone land, or where the ſoil has been moderately limed.

This ſpecies of manure is much eſteemed by the farmer It contains the food of plants ready prepared; but as it is

not capable of loofening the foil by any fermentation, the lands upon which it is laid ought to be in excellent tilth. At prefent, that ufeful article of hufbandry is much diminifhed in goodnefs, owing to the improved methods of extracting the oil from the rape. Heat and preffure are employed in a double degree, and every other method is ufed to the prejudice of the farmer.

Farmers who live in the neighbourhood of large towns ufe abundance of foot. It is an oily manure, but different from the former, containing alkaline falt in its own nature, calculated as well for opening the foil, as for rendering the oily parts mifcible with water.

It is obferved that pigeons dung is a rich and hafty manure. Thefe animals feed chiefly upon grains and oily feeds; it muft therefore be expected that their dung fhould contain a large proportion of oil.

The dung of ftable-kept horfes is alfo a ftrong manure, and fhould not be ufed until it has undergone the *putrid ferment*, in order to mix and affimilate its oily, watery, and faline parts. Beans, oats, and hay, contain much oil. The dung of horfes, that are kept upon green herbage, is of a weaker kind, containing much lefs oil. Swines' dung is of a faponaceous and oily nature, and perhaps is the richeft of the animal manures. When made into a

compoſt, and applied with judgment, it is excellent both for arable and graſs lands.

The dung of ruminant animals, as cows and ſheep, is preferable to that of horſes at graſs, owing to the quantity of animal juices mixed with their food in chewing. And here I beg leave to remark in general, that the fatter the animal, *cæteris paribus*, the richer the dung.

Human ordure is full of oil and a volatile alkaline ſalt. By itſelf, it is too ſtrong a manure for any land; it ſhould therefore be made into a compoſt before it is uſed. The dung of carniverous animals is plentifully ſtored with oil. Animals that feed upon ſeeds and grains come next, and after them follow thoſe which ſubſiſt upon graſs only.

To ſuit theſe different manures to their proper ſoils, requires the greateſt judgment of the farmer; as what may be proper for one ſoil, may be highly detrimental to another.

In order to ſtrengthen my argument in favour of oil being the principal food of plants, I muſt beg leave to obſerve, that all vegetables, whoſe ſeeds are of an oily nature, are found to be remarkable impoveriſhers of the ſoil, as hemp, rape, and flax; for which reaſon, the beſt manures for lands worn out by theſe crops, are ſuch as

have a good deal of oil in their compoſition; but then they muſt be laid on with lime, chalk, marl, or ſoap-aſhes, ſo as to render the oily particles miſcible with water.

The book of Nature may be diſplayed, to ſhew that oily particles conſtitute the nouriſhment of plants in their embryo ſtate. The oily ſeeds, as thoſe of rape, hemp, line, and turnip, conſiſt of two lobes, which, when ſpread upon the ſurface, form the ſeminal leaves. In them the whole oil of the ſeed is contained. The moiſture of the atmoſphere penetrates the cuticle of the leaves, and, mixing with the oil, conſtitutes an emulſion for the nouriſhment of the infant plant. The oleaginous liquor being conſumed, the ſeminal leaves decay, having performed the office of a mother to her tender infant. To perſons unacquainted with the analogy between plants and animals, this reflection will appear ſtrange. Nothing, however, is more demonſtrable.

Fig. 3. ſhews the ſeed-leaves, or placenta, of a turnip, with its radicle and germ. *a.* The germ. *b.* The placenta, or ſeed-leaves. *c.* The radicle.

On the contrary, wheat, oats, peaſe, beans, barley, and rye, keep their placenta, or ſeminal leaves, within the earth; in which ſituation they ſupply the tender germ

with oily nutriment, until its roots are grown fufficiently ftrong to perform the office required of them.

It is ufual to talk of the falts of the earth; but chymiftry has not been able to difcover any falts in land which has not been manured, though oil may be readily obtained from every foil, the very fandy ones excepted.

Marl, though a rich manure, has no falts. It is thought to contain a fmall portion of oleaginous matter, and an abforbent earth, of a nature fimilar to limeftone, with a large quantity of clay intermixed.

Lime mixed with clay comes neareft to the nature of marl of any factitious body that we know of, and may be ufed as fuch, where it can be had without much expence. But as lime ufed in this manner foon recovers the air of which it was deprived during calcination, I would advife unburnt limeftone to be mixed with the clay, which will reduce the expence to little more than digging the materials. If a fmall portion of fand be added to this compofition, it will form a body perfectly fimilar to marl.

It is the opinion of fome, that lime enriches the land it is laid upon, by means of fupplying a falt fit for the nourifhment of plants; but by all the experiments that

have been made upon lime, it is found to contain no kind of falt. Its operation therefore fhould be confidered in a different light. By the fermentation that it induces, the earth is opened and divided, and, by its abforbent and alkaline quality, it unites the oily and watery parts of the foil.

From viewing lime in this light, it is probable that it tends to rob the foil of its oily particles, and in time will render it barren, unlefs we take care to fupport it with rotten dung, or other manures of an oily nature.

As light fandy foils contain but a fmall proportion of oleaginous particles, we fhould be extremely cautious not to overdo them with lime; unlefs we can at the fame time affift them liberally with rotten dung, woollen rags, fhavings of horn, or other manures of an animal kind. Its great excellence, however, upon a fandy foil, is by mechanically binding the loofe particles, and thereby preventing the liquid parts of the manure from efcaping out of the reach of the radical fibres of the plants.

Upon clay the effect of lime is different; for by means of the gentle fermentation that it produces, the unfubdued foil is opened and divided: the manures laid on readily come into contact with every part of it; and the fibres of the plants have full liberty to fpread themfelves.

It is generally faid that lime anfwers better upon fand than upon clay. This obfervation will undoubtedly hold good as long as the farmer continues to lime his clay lands in a fcanty manner. Let him double the quantity, and he will then be convinced that lime is better for clay than fand. It may be juftly anfwered, that the profits will not admit of the expence. I agree. But then it muft be underftood that it is the application, and not the nature of the lime, that fhould be called in queftion. Clay, well limed, will fall in water, and ferment with acids. Its very nature is changed. However, let the farmer who ufes much lime for his clay lands, be inftructed to manure them well, otherwife the foil will become too hard to permit the roots of the plants to fpread themfelves in fearch of food. In confequence of the fermentation raifed in the foil, the fixed air is fet at liberty, and in that ftate of activity it becomes an ufeful inftrument in dividing the tenaceous clay. To lands fo circumftanced, the air, rains, and dews, are freely admitted, and the foil is enabled to retain the nourifhment that each of them brings.

It is the nature of lime to attract oils and diffolve vegetable bodies. Upon thefe principles we may account for the wonderful effects of lime in the improvement of black moor-land. Moor-earth confifts of diffolved, and half

diſſolved, vegetable ſubſtances. It is full of oil. Lime diſſolves the one and aſſimilates the other.

Such lands, not originally worth fourpence *per* acre, may be made, by paring, burning, and liming, to produce plentiful crops of turnips, which may be followed with oats, barley, or rye, according to the inclination of the owner.

To the univerſal principle, oil, we muſt add another of great efficacy, though very little underſtood; I mean the nitrous acid of the air.

That the air does contain the rudiments of nitre, is demonſtrable from the manner of making ſaltpetre in the different parts of the world. The air contains no ſuch ſalt as perfect nitre; it is a factitious ſalt, and is made by the nitrous acid falling upon a proper matrix. The makers of nitre form that matrix of the rubbiſh of old houſes, fat earth, and any fixed alkaline ſalt. The univerſal acid, as it is called, is attracted by theſe materials, and forms true nitre, which is rendered pure by means of cryſtallization, and in that form it is brought to us. In very hot countries the natural earth forms a matrix for nitre, which makes the operation very ſhort.

It is obſerved that nitre is moſt plentifully formed in winter, when the wind is northerly: hence we may underſtand the true reaſon why land is fertilized by being laid up in high ridges during the winter months. The good effects of that operation are wholly attributed to the mechanical action of the froſt upon the ground. Light ſoils, as well as the tough ones, may be expoſed in high ridges, but with ſome limitation, in order to imitate the mud walls of Germany, which are found, by experience, to collect conſiderable quantities of nitre during the winter.

After ſaying ſo much in praiſe of nitre, it will be expected that I ſhould produce ſome proofs of its efficacy, when uſed as a manure. I muſt confeſs that experiments do not give us any ſuch proofs. I ſhall therefore conſider this nitrous acid, or, as ſome philoſophers call it, the *acidum vagum*, in the light of a vivifying principle, with whoſe operation we are not yet fully acquainted.

I have already obſerved, that there ſubſiſts a ſtrong analogy between plants and animals. Oil and water ſeem to make up the nouriſhment of both. Earth enters very little into the compoſition of either. It is known, that animals take in a great many earthy particles at the mouth, but they are ſoon diſcharged by urine and ſtool. Vegetables take in the ſmalleſt portion imaginable of

earth; and the reafon is, they have no way to difcharge it.

It is highly probable, that the radical fibres of plants take up their nourifhment from the earth, in the fame manner that the lacteal veffels abforb the nutriment from the inteftines; and as the oily and watery parts of our food are perfectly united into a milky liquor, by means of the fpittle, pancreatic juice, and bile, before they enter the lacteals, we have all the reafon imaginable to keep up the analogy, and fuppofe that the oleaginous and watery parts of the foil are alfo incorporated, previous to their being taken up by the abforbing veffels of the plant.

To form a perfect judgment of this, we muft reflect that every foil, in a ftate of nature, has in itfelf a quantity of abforbent earth, fufficient to incorporate its inherent oil and water; but when we load it with fat manures, (as in the cafe of old Kitchen Gardens) it becomes effentially neceffary to beftow upon it, at the fame time, fomething to affimilate the parts. Lime, foap-afhes, kelp, marl, and all the alkaline fubftances, perform that office.

In order to render this operation vifible to the fenfes:—Diffolve one drachm of Ruffia pot-afh in two ounces of water; then add two fpoonfuls of oil. Shake the mixture, and it will inftantly become an uniform mafs of a

whitiſh colour, adapted to all the purpoſes of vegetation.

This eaſy and familiar experiment is a juſt repreſentation of what happens after the operation of burn-baking, and conſequently may be conſidered as a confirmation of the hypotheſis advanced.—Let us attend to the proceſs.

The ſward being reduced to aſhes, a fixed alkaline ſalt is produced. The moiſture of the atmoſphere ſoon reduces that ſalt into a fluid ſtate, which, mixing with the ſoil, brings about an union of the oily and watery parts, in the manner demonſtrated by the experiment.

When the under ſtratum conſiſts of a rich vegetable mould, the effects of burn-baking will be laſting. But when the ſoil happens to be thin and poor, the firſt crop frequently ſuffers before it arrives at maturity.

The farmer therefore, who is at the expence of paring and burning a poor ſoil, ſhould beſtow upon it a portion of rotten dung, or ſhambles manure, before the aſhes are ſpread, in order to ſupply the deficiency of oily particles, and he ſhould afterwards keep it in vigour by beſtowing upon it a reaſonable portion of manure, otherwiſe the paring and burning ſuch a ſoil, will, in the end, prove a ruinous practice. On the contrary, when a

judicious courfe of crops is inftituted, and well fupported, the practice may be confidered as beneficial. However, fuch a kind of land fhould on no account be kept long under the plough, but be laid down to grafs, after a few crops, judicioufly chofen, are taken from it. When it is intended to break up meadow-land that is over-run with rufhes, coarfe grafs, and tap-rooted weeds, it is a good practice to pare and burn the furface, taking off a thick turf. This, after a proper drainage, is the beft method of bringing coarfe meadow-land into cultivation; and I apprehend it will not be objected to by thofe land-owners who confider burn-baking as a ruinous practice.

Hitherto I have confidered plants as nourifhed by their roots. I fhall now take a view of them as nourifhed by their leaves. An attention to this part of the vegetable fyftem is effentially neceffary to the rational farmer.

Vegetables that have a fucculent leaf, fuch as vetches, peafe, beans, and buck-wheat, draw a great part of their nourifhment from the air, and on that account impoverifh the foil lefs than wheat, oats, barley, or rye, the leaves of which are of a firmer texture.

Rape and hemp are oil-bearing plants, and, confe-quently, impoverifhers of the foil; but the former lefs fo

than the latter, owing to the greater ſucculency of its leaf.

The leaves of all kinds of grain are ſucculent for a time; during which period the plants take little from the earth; but as ſoon as the ear begins to be formed, they loſe their ſoftneſs, and diminiſh in their attractive power.

The radical fibres are then more vigorouſly employed in extracting the oily particles of the earth, for the nouriſhment of the ſeed.

It is not ſufficient for the farmer to be acquainted with the nature of the different manures and ſoils. He ſhould alſo know the ſhape of the roots of ſuch plants as are uſed in field-huſbandry. The ſoil and roots are ſo intimatly connected, that the knowledge of both becomes eſſential.

Wheat has two ſets of roots. The firſt comes immediately from the grain; the other ſhoots from the crown ſome time after. I ſhall diſtinguiſh them by *ſeminal* and *coronal* roots.

Plants, according to their ſpecies, obſerve a regular uniformity in the manner of ſpreading their roots; for which reaſon the ſame grain cannot be continued long

upon the ſame ſoil. It is not that each takes from the earth ſuch particles as are congenial: The food of all plants is the ſame; only ſome require more, ſome leſs. Some take it near the ſurface, others ſeek it deeper. A careful inſpection of a healthy root will at once demonſtrate the bias of nature. An examination of the ſoil will ſhew how far they will agree. This is the rational baſis of the change of ſpecies, ſo well underſtood in Norfolk, where tap-rooted plants always follow thoſe that root ſuperficially.

To be convinced that we reaſon improperly when we ſay, that every plant takes from the earth ſuch particles as are natural to it, we have only to conſider, that a lemon, engrafted upon an orange ſtock, is capable of changing the ſap of the orange into its own nature, by a different arrangement of the nutritive juices; and daily obſervation teaches us that the graſs of the field is capable of being changed into fleſh and bone; but how this tranſmutation is performed, remains, and perhaps ever will remain, unknown. The ſame maſs of earth, by a certain arrangement of its parts, can give life and vigour to the bitter aloe, and to the ſweet cane; to the cool houſe-leek, and to the fiery muſtard; to the nouriſhing grains, and to the deadly nightſhade. We may eat the earth, and drink the water that moiſtens it, and yet, by a wonderful modification of its parts, it is made to produce both

bread and poifon. All nature is in motion; and, perhaps, there is not a particle of matter that is abfolutely at reft, being employed either in acts of combination or diffolution; two great operations of nature that follow each other in endlefs fucceffion.

To return. Wheat being fubject to the feverity of winter, its roots are wonderfully difpofed to withftand the inclemency of the feafon. A view of their fhape will direct us in the manner of fowing that grain to the moft advantage; and at the fame time enable us to account for fome of the phænomena obfervable in the growth of it.

I have obferved that wheat has a double root. The firft, or *feminal* root, is pufhed out at the fame time with the germ, which, together with the *farina*, nourifhes the plant during the winter before the crown and coronal roots are formed. Fig. 4. reprefents a plant of wheat at this early feafon, when it has only got its feminal root. *a*. The part from whence the coronal root fprings. *b*. The pipe of communication between the firft root and the crown, which, in this early ftage of the plant is covered with a membranous fheath. *c*. The grain with its feminal root. At this feafon the grain is filled with a milky juice for the fupport of the plant, during what may be called its infant ftate.

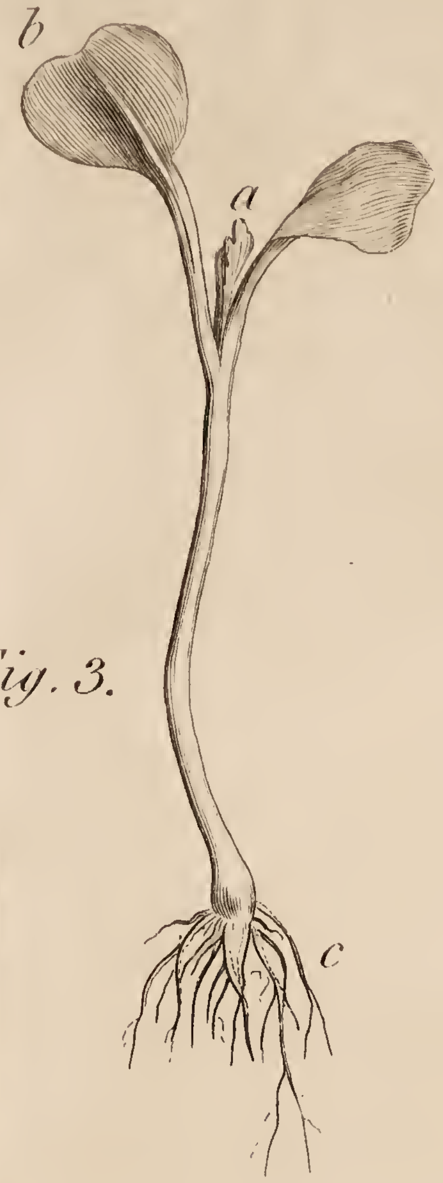

Fig. 3.

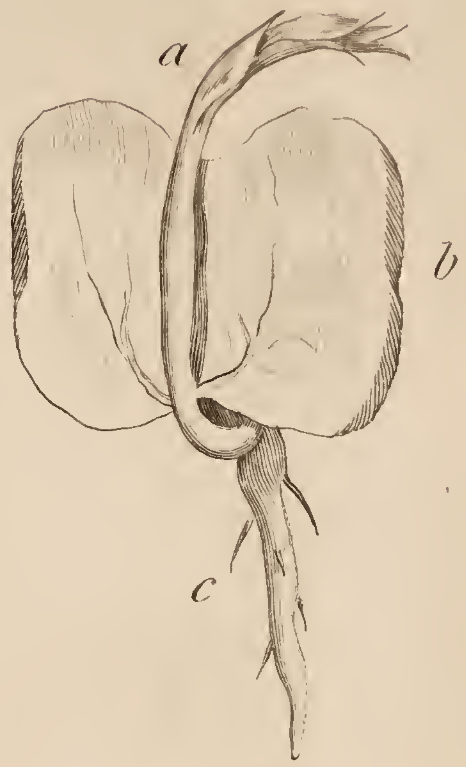

Fig. 1.

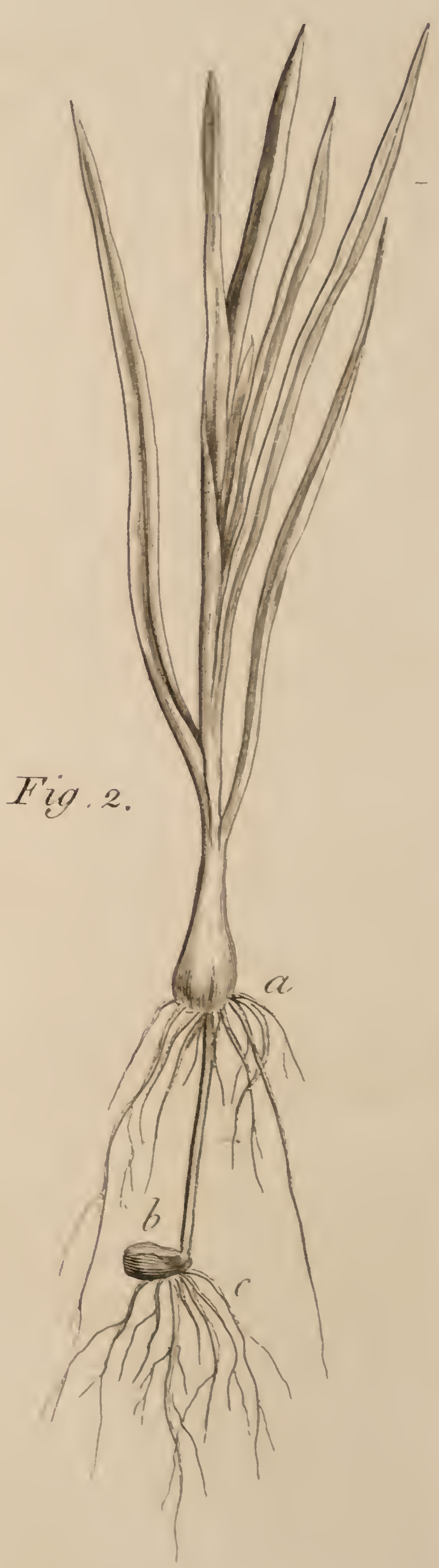

Fig. 2.

Fig. 5.

Fig. 4.

In the ſpring, when the crown has become ſufficiently large, it detaches a number of ſtrong fibres which puſh themſelves obliquely downwards. Theſe are the coronal roots, ſerving to nouriſh the plant till it arrives at maturity. A ſmall pipe preſerves the communication between them and the ſeminal roots. This makes an eſſential part of the plant, and is obſerved to be longer or ſhorter, according to the depth that the ſeed has been buried. It is remarkable, however, that the crown is always formed juſt within the ſurface. Its place is the ſame whether the grain has been ſown deep or ſuperficial. I believe I do not err when I call this *vegetable inſtinct*. As the increaſe of wheat depends upon the vigorous abſorption of the coronal roots, it is no wonder that they ſhould fix themſelves ſo near the ſurface, where the ſoil is always the richeſt. From an attention to this circumſtance, we are led to explain the operation of top-dreſſings. Fig. 2. repreſents a grain of wheat ſown at a proper depth. *a.* The crown with its roots. *b.* The pipe of communication. *c.* The ſeminal roots, with the capſule of the grain. Fig. 5. ſhews a plant of wheat ſown ſuperficially. *a.* The crown and roots. *b.* The ſeminal roots. *c.* The capſule of the grain. Hence it is obvious that wheat, ſown ſuperficially, muſt be expoſed to the ſeverity of the froſt from the ſhortneſs of the pipe of communication. The plant, in that ſituation, has little benefit from its ſeminal root. On the contrary, when the

grain has been properly covered, the feminal and coronal roots are kept at a reafonable diftance. The crown being well nourifhed by means of the feminal root during the winter, fends up numerous ftalks in the fpring. On the tillering of the corn the goodnefs of the crop principally depends. A field of wheat fown by the drill plough, always makes a better appearance than one fown by the harrows. In the firft, the length of the pipe of communication is regularly the fame; but in the other, it is irregular, being either too long or too fhort. From thefe anatomical facts we are led to reafon juftly upon the application of manures. Till the farmer can fcientifically explain the manner that the different kinds of plants feed themfelves, it will be impoffible for him to reduce his profeffion to the ftandard of reafon. Moft farmers are acquainted with the nature and application of heavy manures, but in general they are ignorant of the nature and application of thofe that are light, and which pafs under the name of top-dreffings.

In the northern counties wheat is generally fown late. When the frofts come, the feminal roots that are near the furface, are frequently chilled, fo that they can but imperfectly fupply the plant with nourifhment during the winter. This inconvenience, however, may eafily be prevented by burying the feed deeper, or in other words, by lengthening the pipe of communication.

It will here be neceſſary to remark, that as top-dreſſings can only operate a little way within the ſurface, they are therefore only proper for horizontal feeders, as wheat, oats, barley, and rye. Beans and tap-rooted plants require ſuch heavy manures as are worked into the land by the action of the plough.

It may be objected, that turnips, though tap-rooted, yet receive benefit from top-dreſſings; but it muſt be conſidered that they operate upon the plant by haſtily puſhing it into rough leaf, thereby ſecuring it againſt the fly. After this the turnip flouriſhes or declines in proportion to the richneſs or poverty of the ſoil.

Soot, malt duſt, pigeons' dung, and rape duſt, are conſidered as top-dreſſings. They are conſequently never worked into the land by the plough. In that they eſſentially differ from other manures. When any kind of manure is worked into the land by the plough, we mean to lighten the ſoil; but when we apply top-dreſſings, we only conſider the nouriſhment of the plants, having no regard to looſening the earth. Light, ſandy, and limeſtone lands are beſt managed by top-dreſſings. Stiff loams and clays require lime and rotten dung to break the coheſion of their parts. The laſt remains in the ground for the benefit of the ſucceeding crops; the other is only the food of the year. The tillage farmer, whoſe ſoil is thin,

ſhould pay a careful attention to top-dreſſings. They are the ſoul of his huſbandry.

On the limeſtone lands in Yorkſhire, rape duſt is chiefly uſed; but the price is now ſo much advanced, that the farmer can ſcarcely afford to purchaſe it. An acre of wheat land cannot be dreſſed with leſs than three quarters of rape duſt; four quarters are required for an acre of barley. The price is about 19s. per quarter.

In Flanders, where top-dreſſings are well underſtood, they dry and powder human ordure, which they uſe as a top-dreſſing, and find it of a rich quality. In large manufactories, and in places where a number of people live together, it may be a judicious practice to receive all excrementitious matters upon ſaw-duſt, which, after being frequently turned over, may be converted into one of the richeſt dreſſings, with the advantage of being obtained at a ſmall price. Where ſaw-duſt cannot be procured, coal-aſhes and earth will anſwer the purpoſe equally well.

The farmer ſhould loſe no opportunity to increaſe his quantity of manure. He ſhould be told that even a ſnail, however diminutive, adds ſomething, both to the ſize and richneſs of his dunghill. The public ſewers of all towns; inſtead of emptying themſelves into rivers, ſhould be directed into reſervoirs filled with earth and ſmall rubbiſh;

a contrivance that would produce an accumulation of heavy manure at a ſmall expence.

Having in ſeveral parts of theſe Outlines hinted at the analogy that ſubſiſts between plants and animals, I am induced to think that an extenſion of that beautiful ſubject will not be thought foreign to the object of this diſcourſe.

It is an eſtabliſhed truth, that vegetables are placed in a middle degree between animals and minerals. They are ſuperior to minerals, in having organized parts; but inferior to animals, in being deſtitute of ſenſation.

As they are fixed to a place, they have few offices to perform. An increaſe of body and maturation of their ſeed, ſeem all that is required of them. For theſe purpoſes Providence has wiſely beſtowed upon them organs of a wonderful mechaniſm. The anatomical inveſtigation of theſe organs, is the only rational method of arriving at any certainty concerning the laws of the vegetable œconomy. Upon this ſubject Dr. Hales judiciouſly obſerves, "that as the growth and preſervation of vegetable life is promoted and maintained, as in animals, by the very plentiful and regular motion of their fluids, which are the vehicles ordained by nature to carry nutriment to every part, it is therefore reaſonable to hope

" that in them alſo, by the ſame method of inquiry, con-" ſiderable diſcoveries may in time be made, there being, " in many reſpects, a great analogy between plants and " animals."

From this analogy, many eminent naturaliſts have been led to ſuppoſe a regular circulation of the vegetable juices. M. Perrault, M. Major, M. Marriotte, Malpighi, and Dr. Grew, contended, much about the ſame time, for the circulation of the ſap. According to their microſcopical obſervations, the wood of trees, and the fleſh of plants, conſiſt of fine capillary tubes, which run parallel from the root, through the trunk and branches. Theſe they looked upon as arteries. Other minute veſſels were obſerved running between the wood and inner bark, which they diſtinguiſhed by the name of veins. They alſo deſcribed, very correctly, the tracheæ, or air-veſſels, which take their courſe through the fibres of the wood. Theſe anatomical preliminaries being ſettled, they proceeded to reaſon in this manner:

The root having abſorbed a quantity of nouriſhment from the earth, it is made to aſcend through the veſſels of the wood, by the alternate expanſion and contraction of the tracheæ, aſſiſted by the natural abſorption of the ſap-veſſels themſelves. They ſuppoſed the ſap to be rarified to the degree of a fine vapour, in which ſtate it

mounted upward to the extreme parts of the plant, where, meeting with the external air, it became condenſed into a liquor, and in that form returned to the root by the venal ſyſtem, between the wood and bark. Dr. Hales ſet aſide this doctrine, and, in the moſt ſatisfactory manner, made it appear that the vegetable juices riſe and fall in the ſame ſeries of veſſels, and conſequently have no circulation.

It is remarkable that Dr. Hervey ſhould have been the firſt who eſtabliſhed the *circulation* of the blood, in oppoſition to moſt of the anatomiſts of Europe; and that Dr. Hales ſhould have diſproved the *circulation* of the vegetable juices, contrary to the opinion of every naturaliſt of his time.

The ſeed of a plant, after it has dropt from the ovarium, may be conſidered as an impregnated ovum, within which the embryo plant is ſecurely lodged. In a few days after it has been committed to the earth, we may diſcern the rudiments of the future plant. Every part appears to exiſt in miniature. The nutritive juices of the ſoil inſinuate themſelves between the original particles of the plant, and bring about an extenſion of its parts. This is what is called the growth of the vegetable body.

Every one knows that animals, inftead of being ftrengthened, are enfeebled by a fupply of improper nourifhment. It is the fame thing with regard to vegetables; but with this difference, that animals refufe whatever is improper, while vegetables, from their paffive nature, muft be content with what we give them.

The impregnated ovum of every animal, after it has paffed down the Fallopian tube, and fixed itfelf to the bottom of the uterus, is found to contain the tender embryo within two membranes called Chorion and Amnion. In this fituation the embryo could not long fubfift without a fupply of nourifhment. Nature has therefore beftowed upon it a placenta and umbilical chord, through which the blood of the mother is tranfmitted, for its prefervation and increafe.

Seeds are difpofed, by Providence, nearly in the fame manner. They have two coverings, anfwering to the Chorion and Amnion, and two lobes which perform the office of the placenta. Thefe lobes conftitute the body of the feed, and, in the farinaceous kinds, they are the flour of the grain. Innumerable fmall veffels run through the fubftance of the lobes, which, uniting as they approach the feminal plant, form a fmall chord to be inferted into the body of the germ. Through it the nutri-

ment ſupplied by the placenta, or lobes, is conveyed for the preſervation and increaſe of the embryo plant.

In order that I may be clearly underſtood, it will be neceſſary to obſerve, that the lobes of farinaceous grains are fixed in the earth. They are therefore improperly termed ſeminal leaves, being rather the placenta, or cotyledons of the plant. On the contrary, vegetables that have an oily ſeed, as rape, hemp, line, and turnip, carry their lobes upward, and ſpread them upon the ſurface, in the form of broad leaves. Theſe, though they perform the office of a placenta, are properly ſeminal leaves.

Fig. 1. repreſents the body, or placenta, of a bean, with its germ, radicle, and umbilical ramifications.—*a.* The germ.—*b.* The body, or placenta, with the umbilical ramifications.—*c.* The radicle.

Fig. 3. repreſents the placenta, or ſeed-leaves, of a turnip, with its radicle and germ.—*a.* The germ.—*b.* The placenta, or ſeed-leaves.—*c.* The radicle.

To illuſtrate the ſubject of vegetation, let us take a view of what happens to a bean, after it has been committed to the earth.

In few days, ſooner or later, according to the temperature of the weather and diſpoſition of the ſoil, the ex-

ternal coverings open at one end, and diſcloſe to the naked eye part of the placenta, or body of the grain. This ſubſtance conſiſts of two lobes, between which the ſeminal plant is ſecurely lodged. Soon after the opening of the membranes, a ſharp-pointed body appears: This is the root. By a kind of principle, which ſeems to carry with it ſome appearance of inſtinct, it ſeeks a paſſage downwards, and fixes itſelf into the ſoil. At this period the root is a ſmooth and poliſhed body, and perhaps has but little power to abſorb any thing from the earth, for the nutriment of the germ.

The two lobes now begin to ſeparate, and the germ, with its leaves, may plainly be diſcovered. As the germ increaſes in ſize, the lobes are further ſeparated, and the tender leaves being cloſely joined, puſh themſelves forward in the ſhape of a wedge.

Theſe leaves take a contrary direction to the root. Influenced by the ſame miraculous inſtinct, if I may be allowed the expreſſion, they ſeek a paſſage upward; which having obtained, they lay aſide their wedge-like form, and ſpread themſelves in a horizontal direction, as being the beſt adapted for receiving the rains and dews.

The radicle, every hour increaſing in ſize and vigour, puſhes itſelf deeper into the earth, from which it now draws ſome nutritive particles. At the ſame time the leaves of

the germ, being of a ſucculent nature, aſſiſt the plant, by attracting from the atmoſphere ſuch particles as their tender veſſels are fit to convey. Theſe particles, however, are of a watery kind, and have not, in their own nature, a ſufficiency of nutriment for the increaſing plant.

Vegetables and animals, during their tender ſtates, require a large ſhare of balmy nouriſhment. As ſoon as an animal is brought into life, the milk of its mother is ſupplied in a liberal ſtream, while the tender germ ſeems only to have the crude and watery juices of the earth for its ſupport. In that, however, we are deceived. The Author of nature, with equal eye, watches over the infancy of all his works. The animal enjoys the milky humour of its parent. The vegetable lives upon a ſimilar fluid, though differently ſupplied. For its uſe the farinaceous lobes are melted down into a milky juice, which, as long as it laſts, is conveyed to the tender plant by means of innumerable ſmall veſſels, which are ſpread through the ſubſtance of the lobes. Theſe veſſels, uniting into one common trunk, enter the body of the germ, and perform the office of an umbilical chord. Without this ſupply of balmy liquor, the plant muſt inevitably have periſhed, its root being then too ſmall to abſorb a ſufficiency of food, and its body too weak to aſſimilate it into nouriſhment.

Turnips, and all the tribe of Braſſicas, in oppoſition to moſt of the farinaceous vegetables, ſpread their ſeminal leaves upon the ſurface. Theſe leaves contain all the oil of the ſeed, which, when diluted by the moiſture of the atmoſphere, forms an emulſion of the moſt nouriſhing quality. How ſimilar is this juice to the milk of animals! On account of its ſweetneſs, the ſeminal leaves are greedily devoured by the fly. This demonſtrably proves that oil conſtitutes the nouriſhment of plants in their tender ſtate.

A grain of wheat, as ſoon as the germ has made its appearance, ſhews the milky liquor to the naked eye; but as the plant increaſes in ſize, the balmy juice diminiſhes, till at laſt it is quite exhauſted. The umbilical veſſels then dry up, and the external covering of the grain appears connected to the root in the form of a ſhrivelled bag.

Here is no mortality. From the moment that the ſeed is lodged in its parent earth, the vegetative ſoul begins its operations, and, in one continued miracle, proves the wiſdom and bounty of an Almighty Providence!

It is worthy of obſervation, that farinaceous vegetables and oviparous animals are nouriſhed, in their tender ſtates, nearly in the ſame manner.

We have already ſeen that the embryo plant is ſupported by the farina melted down into a milky liquor,

and conveyed into its body by means of umbilical veſſels, at a time when the radicle was unable to ſupply a ſufficiency of nutriment.

An oviparous animal, from the time that it is brought into light, ſeems to receive all its nouriſhment from without. This, however, is only an appearance. The yolk of the egg, remaining entire during incubation, is received into the body of the animal, and in a manner ſimilar to the paſſage of the milky juice of the vegetable, is ſlowly conveyed into the veſſels of the tender chick. Thus a ſweet nouriſhment is prepared at a time when neither the induſtry of the animal, nor the attention of its mother, could have procured a ſufficient ſupply.

It is wonderful to obſerve the attention of Providence to the infancy of vegetable life! but our wonder is turned into adoration when we obſerve the ſame goodneſs beſtowed upon every part of animated nature: and, to eſtabliſh this important truth, we have only to take a view of the ſtate of an egg on the fourth day of incubation. Fig. 1. repreſents the containing and contained parts of an egg, as they appear on the removal of the fore-part of the ſhell. Fig. 2. The ſhell. Fig. 3. The membranes which line the inſide of the ſhell, and incloſe the whole contents. *a*. The ſhell. *b*. The cavity formed by the membranes, in which a ſmall portion of air is lodged.

c. The inner membrane. Fig. 4. The white which ſerves for the nouriſhment of the chick during incubation. Fig. 5. The yolk, with the ſpeck of life which is analogous to the vegetable germ. *a*. The yolk. *b*. The cicatricula, containing the ſpeck of life. *c. c*. The chalazæ, or twiſted extremities of the membrane that ſurrounds the yolk. Now, if we compare theſe chalazæ to the extremities of an axis paſſing through the yolk, we ſhall find that ſphere compoſed of two unequal portions, its axis not paſſing exactly through its centre. And as the cicatricula, with the ſpeck of life, is always placed on the ſide of the ſmaller portion, it follows that, in all the poſitions of the egg, during the firſt ſix days of incubation, it muſt be uppermoſt, and conſequently neareſt the hen; for the yolk is a body ſpecifically heavier than the white with which it is ſurrounded.

How beautiful are the general laws of Providence! The more we explore them, the more we have cauſe for wonder and aſtoniſhment. Every thing is wiſely diſpoſed; nothing is fortuitous; all is order, regularity, and wiſdom.

A. HUNTER.

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AS the profits arising from the sale of this Publication are to be occasionally applied in clothing a few poor Lunatics, Ladies and Gentlemen who are disposed to give a small sum towards that benevolent purpose, may transmit it to Doctor Hunter, Physician to the Lunatic Asylum, at York.